Marxism: The science of humanity

KEY QUESTIONS IN BIOLOGICAL EVOLUTION

By James Miller, 2019

The evolution of life on earth is both a continuation of the ongoing chemical processes on the planet as well as a new departure growing out of some of the more complex chemical reactions that were in existence on the prebiotic earth. The emergence of life: science knows of no similar departure developing at another place and time. But this does not mean that we are all descendants of a singular, or unitary emergence of the first "life form." It is possible and likely that emerging chemical processes, "proto-life forms," spontaneously arose millions or billions of times, but were not able to sustain themselves for any significant length of time. What is critical for the self-preservation of organic chemical processes is that they must establish a mode of existence that resists the statistical probability of their premature dissolution. They must develop a barrier to protect their integral structure from outside threats. One of the most important aspects of self-preservation is the capacity to generate the energy needed by the chemical reactions that sustain the structure, and this capacity was accomplished through the evolution of photosynthetic processes (or their antecedents) for the development of proto-life or life-forms within an oxygen-free environment, or later, the citric acid cycle in all oxygen-dependent life forms.

Of course, we all die, and the death of individual organisms, combined with their replacement through reproduction is a form of expression of the constant struggle to escape the second law of thermodynamics. The second law is a probabilistic law, which states that in the long run all molecular arrangements are likely to fall into chaotic patterns in the course of their mutual interactions. This understanding provides the answer to whether life is a one-way process, rather than a cyclical one, as people once believed. As Neil DeGrasse Tyson put it in his book, *Death by Black Hole and Other Cosmic Quandaries:*

> With or without warp drives, the long-term fate of the cosmos cannot be postponed or avoided (at least as far as we know now). No matter where you hide, you will be part of a universe that inexorably marches toward a particular oblivion.

> Engels writes (*MECW*, p. 633):

> Nature is the proof of dialectics, and it must be said for modern science that it has furnished this proof with very rich materials increasing daily, and thus has shown that, in the last resort, Nature works dialectically and not metaphysically; that she does not move in the eternal oneness of a perpetually recurring circle, but goes through a real historical evolution. In this connection Darwin must be named before all others. He dealt the metaphysical conception of Nature the heaviest blow by his proof that all organic beings, plants, animals, and man himself, are the products of a process of evolution going on through millions of years.

But the fact that probability is fundamental to life processes doesn't mean that some of us live to 50 or 100, while others live to 1,000 or 10,000. Probability has fostered the development of self-protective constraints within the genome of all life-forms. Once begun, life protects itself by evolving complex forms of constraint to protect against dissolution. These constraints evolve normally and become incorporated into the genomes of individuals and populations by the process of natural selection.

Physics of life

The physical foundation of biological evolution is chaotic and probabilistic molecular activity constrained by the second law of thermodynamics. The speed and energy of the molecules, their elemental composition, as well as the frequency of their collisions are limited by the relative density of the medium as well as the temperature. In relatively localized regions of liquid and gaseous states of matter, processes emerge that promote the initiation and continued elaboration of self-organizing structures. These occur lawfully, in accordance with the varying probabilities that are generated within the molecular chaos of liquid and gaseous states. But these self-organized states of matter, viewed as the precursors of metabolic cellular activity, as forerunners of life, have the potential to become individual metabolic cycles, then cells and cellular components, then multicellular organisms, then reproductive lineages. All these processes and conditions are only limited stopgaps to stave off the statistical inevitability of dissolution and death of all relatively stable organized structures that have emerged. (The heat death of the universe.)

But given that each stage of evolution produces a new configuration of structural processes, each new step is determined by the probabilities inherent in the already existing configuration of molecular complexes as they interact with their environments. The radiation of living forms seen in the tree of life shows the continued interaction among the changing assemblages of populations, as all species contribute toward the ongoing evolution of the planetary biosphere. The changing external circumstances which constrain the range of probabilities faced by each population determine the features that emerge in the continuous adaptation of species through natural selection.

Life is not only a succession of myriads of populations and species, it is also a constant thermodynamic process, generating entropy at the same time as it generates self-organizing molecular structures. The balance of life is the equilibrium established by something that grows only through strife; organic beings that survive—for a time—but are constantly dying while they survive, since every process that sustains their growth and survival is in a constant battle with thermodynamic dissolution. Entropy wins in the end, for every living creature, as well as for every component of the universe. The universe is speeding toward its final heat death, a process that embraces everything—galaxies, stars, planets—all its substance.

Beginning with Darwin, the recognition of natural selection provided a great leap forward in understanding how living nature keeps producing new species and old ones go extinct. After the turn of the 20th century, the recognition of the principles of Mendelian inheritance added specific knowledge about the underlying principles of the preservation of the characteristics of the parent in the offspring, as well as their modification. With this, the science of genetics began to develop, without yet having discovered the gene itself. Knowledge of inheritance and the history of various genetic lineages increased through the analysis of fossils, but the lack of knowledge of what were the specific molecules that carried genetic information remained an obstacle to understanding the mechanisms of evolutionary change. This question was resolved in 1953 with the discovery by Francis Crick and James Watson of the helical structure of DNA, the molecule that carries the genetic code.

Although biological science is continually providing new discoveries, we need to know more about the transition from biological life to social life for our own species. Once organisms exist on earth, the varied and changing conditions in their environments challenge their continued existence. They must adapt or die, whether as individuals, as populations, or as species. In trillions of random biochemical transformations, together with the preservation of their useful effects, they evolve the biochemical means to preserve their living existence. As species evolve and environmental pressures change, an immense variety of survival tactics and mechanisms develop within an ever-branching array of biological species. A good book to read on this subject is *The Vital Question: Energy, Evolution, and the Origins of Complex Life,* by Nick Lane.

Life emerged in watery environs some 3.7 billion years ago on our planet, and over time multicellularity, reproduction, mobility, predation, and many other survival strategies developed. For every fundamental shift in corporeal design and function, there was a long evolution of potentials and precursors paving the way for such a change. No new possibility is realized until that possibility itself reaches a certain stage of maturation. Thus, the development of lungs to breathe air, or limbs for terrestrial locomotion, developed only as a result of innumerable antecedent structures and functions. Every condition is an outcome of some precondition; every precondition is itself a consequence of what has gone before.

Group evolution

The evolution of animal life has provided many forms of group life, which itself is a survival strategy optimizing, in a given environmental context, the survival of these groups as units that make up a local population. Each species is made up of one or more populations, some near, some far. The genetic makeup of the species drives the formation and proliferation of group life, and this opens up the possibility of a variety of modes of collaboration and cooperation among individuals within groups. From fish swimming in synchronized schools, and geese flying in geometrically ordered flocks, to the more complex forms that are seen in groups of higher mammals, the primates. Living in groups is itself a survival strategy, since it offers the possibility of developing, and drawing upon, the survival advantages inherent in combined activity. Once group life exists, it becomes possible to speak of social life, that is, activities that are determined by the interaction among the animals in the group.

Group life among bees, ants and wasps are well understood as forms of interdependence of individual organisms characterized by specialization of individuals into complementary functions within a population. Some individuals focus on fulfilling the nutritional needs of the entire population while others serve to reproduce more individuals. In this group life solution, division of labor within the population makes its appearance among insects that lack the capacity to plan or think about their behavior. Different functional capacities are developed within the genome through natural selection, and the ratio of reproductive individuals to nutritional individuals is in any population is determined by genetically driven responses.

Natural selection acts upon individuals living in groups to select for genetic changes that provide social behavior that proves to be beneficial for survival not only of individual members of a group, but for the group as a whole. Most people are familiar with the gene-directed activity that results in reproduction. Also, behavior that minimizes losses of population through predation are selected for: the ability to detect danger, rapid responses to threats, finding places to hide from danger, etc. Animals and plants evolve internal structures and functions, such as the immune system, that protect the physical integrity of the organism. Migratory behavior among many bird species maximizes the conditions for survival by moving to areas where more food is available.

A certain controversy around the concept of "group selection" began to be debated among biologists in the early 1960s, as described by Robert Boyd and Peter J. Richerson in "Transmission coupling mechanisms: cultural group selection" in the *Philosophical Transactions of the Royal Society* 365 (2010).

> The modern group selection controversy began in the early 1960s when Wynne-Edwards (1962) proposed that a number of interesting bird behaviours evolved because they promoted group survival. Populations in which the behaviour was common survived and prospered, while those in which it was rare perished.
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> … The real scientific question is always: does the population structure in question lead to selection that favours genetic variants of interest? … The answer to this question is fairly clear: only when groups are small or there is very little gene flow between them.

A gene mutation that arises in the reproduction process can affect a member of a local interbreeding population. This mutation, if it provides a selective advantage within the local environment, will tend to spread to other members of the population in which it originates. This mutated gene will tend to proliferate in the population, making this particular population different from other populations of the same species, which might be located nearby or at a great distance. In most cases this difference might not matter to the differential fitness between this changed population and the other populations of the same species. Each different local population, of course, experiences its own course of adapting to environmental conditions and, depending on the different environmental pressures, this might involve many combinations of gene variants that provide a multiplicity of adaptive traits.

Mutations that are introduced by errors in the DNA of the gametes often affect the offspring of a breeding pair. These can be beneficial, neutral, or deleterious to these offspring. The dividing line between deleterious and beneficial might have to do with the functioning of the liver, the endocrine glands, the bone structure, the visual system, etc. Some evolutionary lineages develop genes that influence social, or group, behavior, as one mutation spreads throughout a population and affects the inherited physiological foundation of the social bonds within each population. This kind of evolution often affects group cohesion and communication. According to Nature.com (https://www.nature.com/scitable/knowledge/library/how-does-social-behavior-evolve-13260245/):

> Social behavior consists of a set of interactions among individuals of the same species. A wide range of sociality occurs among animals. Some animals rarely if ever interact with one another, even when it comes to issues of parental care. Examples of relatively asocial animals include mosquitoes and polar bears. Highly social organisms live together in large groups, and often cooperate to conduct many tasks. Examples of social groups include packs of wolves and schools of fish. The most highly social animals form tightly knit colonies and include all ants and termites, some bees and wasps, and a few other organisms.

Among mammals, the bond between mother and offspring is another kind of genetically conditioned relationship which links the behavior of mother to newborn. This system of adaptive genes includes the entire reproductive system of the mother, which regulates reproductive organs as well as the endocrine glands. The males of the species have their own reproductive genes, which facilitate the production of viable offspring as their purpose and result. The behaviors that are prompted by this complex three-way interaction of the genetic systems are a form of group selection which is critical for the perpetuation of any sexually reproducing species.

In *The Symbolic Species,* p. 28, Terrence Deacon refers to this aspect of evolution (in this case with regard to our own species):

> It goes without saying that a more articulate, more precise, more flexible means of communicating should always be an advantage, all other things being equal. In terms of cooperative behaviors, a better ability to pass on information about distant or hidden food resources, or to organize labor for a hunt, or to warn of impending danger, would be advantageous for kin and the social group as a whole. Better communication skills might also contribute to more successful social manipulation and deception. The ability to convince and mislead one's

> competitors or cooperate and connive with one's social and sexual partners could also have provided significant reproductive advantages, particularly in social systems where competition determines access to defendable resources or multiple mates. In fact, it's difficult to imagine any human endeavor that would not benefit from better communication. Looked at this way, it appears that humans have just developed further than other species along an inevitable progressive trend toward better thinking and better communicating.

But we must keep in mind that the forms of social behavior that evolved to benefit fish, ants, or birds occurred through processes that were strictly genetic. These creatures possessed neither foresight nor the ability to learn through observing the behavior of others in the population. This inability to learn was gradually overcome through the developments occurring within populations whose social cohesion causes individual behaviors that synchronize with the behaviors of others in the group. The ability to learn from others then becomes possible through the evolutionary elaboration of neural networks and their connections to various forms of sensory input, which allows a more multi-faceted awareness of the environment and the activity of one’s fellow creatures.

However, the behavior of birds can demonstrate how instinctual behavior can be combined with a highly specific form of learning. This is an indication that genetically controlled behavior is not strictly isolated from learned behavior but can constitute a link to the latter. Male birdcalls, for example, allow for females in the population to respond in a stereotypical manner—for mating—but only if they learn how to recognize a specific call during a specific window of opportunity. This is an example of learning that occurs within a highly restricted frame of reference, but once evolution opens the door for any kind of learning, then its further development exists in the form of new genetic potentials that allow for an expanded range of possible learning adaptations. Further, growing male birds must learn the species-specific mating call during a delimited window of opportunity. They must hear the adult bird call and begin to mimic that call. If they fail to hear the call during their window of opportunity, they will not learn the call and will not be able to attract a mate.

Genes and behavior

As biological evolution advances towards increased ability to learn by imitating others in a group, as among primates and their hominin successors, culture begins to add new capabilities that go beyond genetic inheritance and surpass the ancestral forms of learning through gene-based mimicry. Among the mammals, including monkeys and apes, culture is limited to what the growing animals can absorb in their learning phase, and generally there is little difference between one population and another within a given species (although the uniformity of genomes diverges over time among populations that remain isolated from each other). As the first hominins emerge, the learning process becomes more extensive, and as the process continues to develop there is greater and more varied feedback from the learned behaviors to the evolving genomes of these species. In fact, the genetic adaptations that promote learning by the members of a group not only transform the creative powers of the group, but also lead to the increasing ability to mold and transform, not only the physical, but also the cultural environment to which the offspring are adapting. In other words, the process of natural selection continues to weed out those offspring who are least able to adapt to their environment, which is increasingly an artificial environment. If adapting behaviorally to the natural environment is considered "primary" adaptation, then as the population alters this natural environment while creating an artificial one, there emerges a "secondary" adaptation. This kind of adaptation is called "dual inheritance theory," or "gene-culture coevolution."

This insight, of course, is derived from the understanding of the basis of biological evolution, natural selection, discovered and presented to the world by Charles Darwin. This gave an unprecedented opportunity to all those capable of sustained scientific inquiry to recognize this new finding, and to investigate further the causes of biological change. As Engels remarked (MECW, vol. 25, p. 65):

> It is true that Darwin, when considering natural selection, leaves out of account the causes which have produced the alterations in separate individuals, and deals in the first place with the way in which such individual deviations gradually become the characteristics of a race, variety, or species. To Darwin it

> was of less immediate importance to discover these causes—which up to the present are in part absolutely unknown, and in part can only be stated in quite general terms—than to find a rational form in which their effects become fixed, acquire permanent significance.

Darwin was not uninterested in the causes of variation in the offspring of reproducing species, but at the time *Origin of Species* was published, 1859, only speculations were within Darwin's reach. Later the sweet-pea inheritance experiments conducted by the Austrian monk, Gregor Mendel, came to light, first in an article in a scientific journal published in 1866. It's possible that Darwin had some knowledge about Mendel's conclusions, but if so, there is no evidence of it. Darwin died in 1882, apparently without having absorbed Mendel's findings. Mendel's work only came to be known to the world in 1900 with the rediscovery of his writing by Hugo de Vries and Carl Correns. (See *Genetics,* October 1, 2016, by Daniel Fairbanks and Scott Abbott.)

In any case, Darwin's meticulous explanations, based entirely on verifiable scientific foundations, made a big impression. His theory became a flashpoint of controversy, marking it one of the greatest episodes in the history of the triumph of science over supernatural and religious dogmas. Engels continues (*ibid.*):

> Moreover, if Darwin produces his individual transformations out of nothing, and in so doing applies exclusively "the wisdom of the breeder", the breeder, too, must produce *out of nothing* his transformations in animal and plant forms which are not merely imaginary but real. But once again, the man who gave the impetus to investigate how exactly these transformations and differences arise is no other than Darwin.

Engels provides a criticism of Darwinism by saying (*ibid.,* p. 583):

> Darwin's mistake lies precisely in lumping together in "NATURAL SELECTION OR THE SURVIVAL OF THE FITTEST" two absolutely separate things:
> 1. Selection by the pressure of over-population, where perhaps the

> strongest survive in the first place, but can also be the weakest in many respects.
> 2. Selection by greater capacity of adaptation to altered circumstances, where the survivors are better suited to these circumstances, but where this adaptation as a whole can mean regress just as well as progress (for instance adaptation to parasitic life is always regress). The main thing: that each advance in organic evolution is at the same time a regression, fixing one-sided evolution and excluding the possibility of evolution in many other directions.
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> This, however, a basic law.

Engels here recognizes the dichotomy between regressive or progressive evolution. It seems that Darwin recognized it as well. Regressive evolution, or devolution, involves a loss of some characteristic previously gained in the course of adaptive evolution. Cave fish, for example, lose their eyesight. But this loss, or regress to a lower stage, is compensated by the gain of features permitting a better adaptation to lightless environments. Likewise, the adaptations of land-based mammals to an aquatic world, such as those achieved by dolphins and whales. They lost their "fingers" and "toes," products of their antecedent terrestrial evolution. Their flippers became a strong adaptive trait for living in the sea, not to mention their respiratory adaptations.

Monika Espinasa and Luis Espinasa address the question of vision loss in cave fish in "Losing Sight of Regressive Evolution" in *Evolution: Education and Outreach,* October 2008:

> This is not as simple as it sounds. A fish with eyes sees nothing in the darkness of a cave, but neither does his blind counterpart. So, what is the advantage to losing eyes? Can natural selection act to eliminate something that is irrelevant? If you or the students struggle with this question, do not worry. You are in good company. Darwin himself struggled with regressive evolution, and in particular, the loss of eyes in cave fish puzzled him. With his characteristic and extraordinary insight, a picture was beginning to materialize

> in his mind; yet, for lack of a sound alternative, in the end Darwin still invoked disuse:
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> "By the time that an animal has reached, after numberless generations, the deepest recesses, disuse will on this view have more or less perfectly obliterated its eyes, and natural selection will often have effected other changes, such as an increase in the length of the antennae or palpi, as a compensation for blindness."
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> The non-Darwinian component of Darwin's conclusion caused him great frustration, but without knowledge of genetics, he could not begin to put his finger on precisely how traits in disuse might degenerate or disappear. He eventually fell back into Lamarckism, but not without reluctance:
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> "It is scarcely possible that disuse can go on producing any further effect after the organ has once been rendered functionless. Some additional explanation is here requisite which I cannot give."

I would add here that Darwin's difficulty in interpreting how the question of "disuse" fit into his theory of natural selection is related to the inability, at that time, to elucidate the material source of inheritance, due to the lack of knowledge of this critical aspect of the science. Engels' criticism of Darwin on this point is quite apt, when he avows, "that each advance in organic evolution is at the same time a regression, fixing one-sided evolution and excluding the possibility of evolution in many other directions." Engels, with his training in dialectics, was able to develop a more all-sided, comprehensive appreciation of the question. In evolutionary points of departure, there is always "the road not taken" which accompanies the road taken.

Some new species adapted in such a way that could give rise to subsequent species with improved features that could be handed down to their successors in this or that lineage. For example, skin, hearing, vision, feathers, hooves, etc. But there have existed millions of species, now extinct, which had ears, feathers, eyes, and hooves. Again, the fittest have survived—at least for a time—adapting better than their less successful nearest neighbors.

Gene-culture coevolution

Much later, by the 1950s, the science of evolutionary biology had arrived at the "modern synthesis," based on the recognition of DNA as the carrier of genetic information, and how it acts to determine "the survival of the fittest." But is biological evolution a process driven by natural selection alone (including sexual selection as explained by Darwin)? Or are there other modes of the emergence of new genetic varieties, sub-species and species? C. Lloyd Morgan and James Baldwin pointed to other ways in which new genetic types, or genome variants within a population, might arise. They argued that what began as learned behavior (a variation of behavior not determined by the genes alone, but by learned responses to environmental stimuli) eventually became encoded in the genes. In other words, they described environmental feedback effects having an impact on the genome. This means that, starting with given genetic potentials existing within an individual or a group, learned behavior develops which causes alterations in the genes carried by the individual or population. This this kind of behavior-driven genetic evolution has been observed more than once in birds and mammals, long before the development of primitive culture in the primate lineages.

According to Terrence Deacon, writing on C. Lloyd Morgan's contribution to the discovery of the Baldwin effect, explained, "In the 1890s, he co-discovered an evolutionary mechanism (independently with James Mark Baldwin, for whom the effect is now named) by which strict natural selection could produce Lamarckian-like effects. He argued that behavioral (and thus goal-driven) responses to environmental challenges, including those that could be learned, might become assimilated into inherited adaptations in future generations because of the way they would alter the conditions of natural selection."

In 1896, an American psychologist James M. Baldwin (1896d) proposed "a new factor in evolution". He assumed that if an individual is capable of acquiring an adaptive behavior postnatally, addition of such a learning process in the context of the evolutionary search potentially changes the profile of populational evolution; learning paves the path of the evolutionary search so that the burden of the evolutionary search is eased. In addition, this special synergy of learning and evolutionary search has a further effect; a phenomenon in which "a behavior that was once learned may eventually become instinctive" (Turney et al. 1996). (Yamauchi, 2004)

This kind of analysis of selective adaptation to environmental conditions that are the result of the conscious, or learned, behavior and activity of a given species, was discovered by Conwy Lloyd Morgan and developed further by James Mark Baldwin. This process has been referred to as Baldwinian evolution. As Terrence Deacon explains in *Incomplete Nature: How Mind Emerged from Matter* (p. 156):

> [Morgan] argued that behavioral (and thus goal-driven) responses to environmental challenges, including those that could be learned, might become assimilated into inherited adaptations in future generations because of the way they would alter the conditions of natural selection.

Deacon explained further in *The Symbolic species,* p. 322:

> Baldwin suggested that learning and behavioral flexibility can play a role in amplifying and biasing natural selection because these abilities enable individuals to modify the context of natural selection that affects their future kin. Behavioral flexibility enables organisms to move into niches that differ from those their ancestors occupied, with the consequence that succeeding generations will face a new set of selection pressures. For example, an ability to utilize resources from colder environments may initially be facilitated by seasonal migratory patterns, but if adaptation to this new niche becomes increasingly important, it will favor the preservation of any traits in subsequent generations that increase tolerance to cold, such as the deposition of subcutaneous fat, the growth of insulating hair, or the ability to hibernate during part of the year. In summary, Baldwin's theory explains how behaviors can affect evolution, but without the necessity of claiming that responses to environmental demands acquired during one's lifetime could be passed directly on to one's offspring.

One example often noted in discussions of Baldwinian evolution has to do with the evolution of dam-building mountain beavers. This approach to evolutionary dynamics is referred to as "niche construction theory" which deals with the many ways in which the genetically-driven activity of some species alters the environmental "niche" to which the newly born (or hatched) offspring must adapt. Richard Lewontin explains this phenomenon on the University of St. Andrews website:

https://synergy.st-andrews.ac.uk/niche/niche-construction-and-evolution/

> When a beaver builds a dam and lodge, creating a lake and influencing river flow, it not only affects the propagation of dam-building genes, but it dramatically changes its local environment, affecting nutrient cycling, decomposition dynamics, the structure of the riparian zone, and plant and community composition and diversity *(8)*. It follows that beaver dam building must also transform selection acting on a host of other beaver traits, influencing subsequent beaver evolution. The active agency of beavers in constructing these modified selection pressures and thereby acting as co-directors of their own evolution (not to mention that of other species) currently goes unrecognized.

It becomes ever more crucial to understand Baldwinian evolution and niche construction theory as evolution proceeds onward through the primates, hominin species and Homo sapiens. Gene-culture coevolution is not something "new," but an elaboration of processes that have been in existence for millions of years. Biological evolution on earth is the progenitor of multiple forms of complexity which themselves continue to ramify and differentiate. As mentioned above, nothing is "new" in life and nature. Everything proceeds from the potentials created in the processes of growth and development; everything that comes into existence is a result of the realization of potentials.

Again, taking from Terrence Deacon (*ibid.* p. 326):

> Of all the forms of adaptation, the flexibility to learn new behavioral responses during one's lifetime can produce the most rapid and radical evolutionary consequences. Indeed, the ability to learn and thus inherit acquired behaviors may be one of the most powerful sources of evolutionary change. It provides an organism with access to a repertoire of potential adaptations, and so

> amplifies and extends the range of the behavioral predispositions that can be "sampled" by natural selection. A learned behavioral response can be genetically assimilated to become a behavioral predisposition by virtue of the costs that it imposes on the organism.

While many recognize the valuable contribution that Darwin's theory of natural selection has made to understanding how humans came to be the way they are, still others have been awestruck by the level of complexity that has developed through the evolution of individual human creativity, cognition, language skills and other traits. The exponents of "intelligent design" hypotheses claim that human capacities are far too complex to have been developed through some "random" process. Many biologists have responded to this, calling attention to the creative processes of natural selection. Richard Dawkins' book, *The Blind Watchmaker,* is a good source for this approach.

Terrence Deacon, for his part, in his article "A role for relaxed selection in the evolution of the language capacity" in *PNAS*, May 11, 2010, criticizes the departure from natural selection theory by Noam Chomsky on the origin of language:

> For the most part, however, worries about the sufficiency of natural selection theory to account for our language capacity have simply been ignored by contemporary theorists. Some of the more prominent approaches to the origins of language avoid the issue of selection altogether by attributing this ability to an astonishingly lucky accident of genetic mutation. Previously, it was noted that Chomsky has attributed this unique capacity to a salutatory event in which this ability arose suddenly and irrespective of honing by natural selection.

But to argue for a "lucky accident" is to abandon a scientific approach and appeal to some "unexplained" lapse in the normal course of evolutionary development. On the other hand, we do acknowledge that not "everything" can be explained at the current moment, and there is much yet to be discovered. However, in this case, a more rigorous appreciation of natural selection theory can provide a more rigorous explanation of the evolution of complex structures and capacities.

Deacon continues (*ibid)*:

> … Although neo-Darwinism is indeed based on the assumption that accidental genetic changes contribute to the phylogenetic diversification of traits, this does not imply that complex functional organization arises by accident. This overemphasis on the creative role of variation reflects a tendency to downplay the fact that what varies must be generated by processes of reproduction and development. It is the spontaneous variation of these generative processes that provides the raw material from which natural selection sculpts, so to speak, and so the properties of these generative mechanisms must also be considered. This expansion of focus has given rise to a view of the evolutionary process often called *evodevo*, because it specifically takes account of the constraining and biasing influences of these generative processes. Highlighting this aspect of the evolutionary process will be the focus of this essay.

The evolution of language

A variant of this argument is proposed in Deacon (*The Symbolic Species*, p. 328), where it is suggested that the regular use of prelinguistic symbolic communication (or protolanguage) created what amounts to a socially constructed artificial niche that in turn imposed novel cognitive demands on hominid brains. This early articulation of what has come to be called "niche construction" theory (*The Symbolic Species*, p. 328) argues that, analogous to the evolution of beaver aquatic adaptations in response to a beaver-generated aquatic niche, a constellation of learning biases and changes of vocal control evolved in response to the atypical demands of this distinctive mode of communication. To the extent that this mode of communication became important for successful integration into human social groups and a critical prerequisite for successful reproduction, it would bring about selection favoring any traits that promoted better acquisition and social transmission of this form of communication. Unlike Baldwinian arguments for the genetic assimilation of grammatical and syntactic features of language, however, the niche construction approach does not assume that acquired language regularities themselves ever become innate. Rather it implicates selection that favors any constellation of attentional, mnemonic, and sensorimotor biases that collectively aid acquisition, use, and transmission of language.

A new relationship evolves between the lives of animals and the natural environment in which they find all their opportunities and challenges. As members of a group their mode of interaction within the group creates a new interaction with the environment. New possibilities emerge to utilize the potentials of combined activity in the struggle for existence. In predation, for example, hunting prey in groups offers advantages not available to lone hunters. Witness the tactics employed by wolf packs, lion prides, or chimpanzee groups. In self-defense animals find strength in numbers when faced with a dangerous predator. Animal groups combine the young and old members, those with experience and those just starting out in life. The older and wiser animals set the example for the youngsters.

We recognize behavior acquired by learning as a social function which stands in contrast to behavior which is determined by genetically driven biochemical reactions. Ants or spiders don't need to learn, since whatever they need to do already exists as a system of genetic potential from the moment of hatching. Yet there is continuity from the spider to the chimpanzee, at least when it comes to the modes of expression of inner potentials. Even the most primitive organisms experience constant feedback from the external world, and it is this feedback that provides the basis for action. The genetic regulatory system constantly alters the inner biochemical environment of the cells, producing more or less of specific types of proteins, nucleic acids, etc., and these in turn respond in ways that are determined by the other chemicals that surround them. What is common to all forms of life is the ability to react differently when the environmental stimulus changes. Bacteria can move in a medium, and will move in the direction which increases their contact with a nutrient.

Among non-human primates, to a certain extent among humans as well, the bond that forms between mother and offspring is the center of social life. Given that the young must mature and eventually replace the old, it is necessary that they learn whatever survival skills already exist within the group. Among the higher primates, there is much that must be learned to master the necessary survival skills. It is primarily through the observation of the mother's activities by the developing juvenile that such skills are initially learned: cracking nuts, fishing for ants, how to identify fruits that are good to eat and those to avoid, etc.

What we know as “culture” is learned behavior which varies from one population to another within the same species and is not a result of differences in the genetic potentials. These cultural differences resulting from social learning have been observed among different chimpanzee populations but are generally not observed among lower primates. Among hominins and humans, it is now widely accepted that “gene-culture coevolution” has been developing a growing range of complex gene-culture interdependencies. This means that hominin and human cultures create patterns of behavior that alter the group activities and modify, as well, the relationship of the group to the natural environment. It is this process that has permitted us to separate our species so decisively from all others. One of the researchers that has developed this thesis is Joseph Henrich, author of *The Secret of Our Success,* (Princeton University Press, 2016). Henrich writes (in “A cultural species: How culture drove human evolution,” a science brief for the American Psychological Association, Nov. 2011):

> Long before the origins of agriculture, humans expanded across the globe, from the arid deserts of Australia to the frozen tundra of the Canadian Arctic. Surviving in this immense diversity of habitats depended not on specific genetic adaptations, but on large bodies of culturally transmitted know-how, abilities, and skills that no single individual could figure out in his or her lifetime (e.g., blowguns, animal tracking). Lacking local cultural knowledge, many an explorer has perished in supposedly “harsh” environments in which local adolescents would have easily survived (Boyd, Richerson, & Henrich, 2011a). Even among foraging societies, humans show an immense variety of social organizations, group sizes, kinship structures, and mating patterns: more diversity than the rest of the primate order combined (Henrich & McElreath, 2007). Ethnographically, this diversity is at least partially rooted in culturally acquired and widely shared social rules. No other species depends on cultural information to this degree, and paleo-anthropological evidence increasingly suggests that culture appears early in

> the evolutionary history of our genus (Alperson-Afil et al., 2009; Brown et al., 2009). Overall, much theory and evidence now converge to indicate that we are an ultra-cultural species —unlike any other—whose brains, genes, and biology have long been shaped by the interaction between cultural and genetic evolution. Culture appears to have opened up entirely new evolutionary vistas not available to less cultural species.

But we have seen that genetically-driven behavior, however varied and changeable it might be, does not involve the transmission of knowledge from one individual to another. Yet the potential exists for memory and communication to develop as a function of cerebral activity. As the gene-culture complex evolves it spurs the growth of the cerebral cortex, hence the size of the brain in relation to the body. The organism responds differently to different environmental stimuli and these responses then become stored as a range of genetically-determined biological potentials. As this process goes forward, more neurological and cognitive potentials emerge, creating space for more advanced cultural diversity and cognitive capacities. The hormonal regulatory systems continue to evolve to respond to the ever-changing needs of the individuals and the communities they belong to and allow for more flexible and creative solutions to problems.

Once nervous systems have evolved through the specialization of precursor cells that can link and coordinate different tissues, together with the development of neurotransmitter molecules that can form associations among the nerve cells, the stage is set for the emergence of more complex memory functions. Previous bodily movements and responses can be stored for future use and for further development. Thus, animals go through stages of individual maturation which involves, among other things, the accumulation of memories stored in the nervous system while the various biological capabilities approach maturity. This memory storage is not yet consciousness, but the emergence of conscious memory and reasoning is developed through this evolutionary process.

The life cycles of individuals in a group are interwoven with their fellow group members. Group life influences the development of the physical qualities and behavior; evolution promotes the adaptive processes that improve the cohesion and effectiveness of the group. The senses are developed to enhance and refine social forms of recognition and communication between individuals in a group. As anatomical and physiological processes mutually condition one another, so do individual and social capacities each provide the context for the evolution of the other. As the anatomy of the ear evolves to support advances in the transmission of sounds from the environment to the brain, so the evolving neurological capacity to hear and identify sounds provide the conditions for the further evolution of the auditory anatomy.

Likewise, the evolution of the individual's sensitivity to external auditory signals evolves in the context of group life, within which vocalizations develop, the production of sounds. These sounds, which among mammals are produced in the upper respiratory tract, have the capacity to become recognizable signals to other members of the group. Vocalizations then evolve in concert with changes in the auditory apparatus, and vice versa. As hearing gets more acute and discriminating, different vocal sounds within the group can take on higher levels of significance for the survival of the members of the group. Among birds the calling and recognition of calls promotes the maximization of reproductive success, the passing of the best adapted genome to the offspring. Among mammals, the example of the vervet monkey danger calls is a well-known example of the differentiation of vocalizations combined with specialization of the auditory process to respond differently to different calls.

Every individual animal, as an adult, is a coherent anatomical unit. It can live or die without necessarily affecting the survival others in the group, depending on circumstances. Reproduction and rearing of offspring involve a special form of dependency, critical for the continuity of the group. The group is more than a collection of individuals, because groups evolve interdependencies which mutually condition one another. This process results in the optimization of the adaptive advantages of group life. Group life involves primarily the localization, identification and consumption of edible foods and the avoidance of predation.

Both problems are situated on the borderline of two different areas of developing matter: the emergence of life between chemistry and biology; the beginnings of humankind between biology and human history. What scientific investigators are called upon to explain is how and under what circumstances phenomena belonging to a lower order of existence advanced to a higher level and became converted into a qualitatively different form of being.